IS 7046 (1993): Inland vessels - Harbour tugs - Guide for selection [TED 18: Inland, Harbour Crafts and Fishing Vessels]

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भारतीय मानक

अन्तर्देशीय जलपोत — बंदरगाह टग — चयन की मार्गदर्शिका

(पहला पुनरीक्षण)

Indian Standard

INLAND VESSELS — HARBOUR TUGS — GUIDE FOR SELECTION

(First Revision)

UDC 629·12 : 629·124·2 : 620·1

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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Inland and Harbour Craft Sectional Committee, TED 18

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Inland and Harbour Craft Sectional Committee had been approved by the Transport Engineering Divisional Council.

This Indian Standard was first issued in 1973. In this first revision, the latest technological developments in the field obtained through various technical papers and the experience gained over the years by port authorities and operators have been considered. However, it may be noted that while selecting a tug the principal characteristic chosen and its effect on other related characteristics has to be taken into account. The design of a harbour berthing tug depends on several mutually dependent factors with the berthing vessels.

With the increase in size of both tankers and bulk carriers and the advent of container ships requiring short turn-around time it has become necessary to augment the available port facilities. This directly necessitates the re-appraisal of berthing requirements and the harbour berthing tugs. Developments are underway to equip some of the large tonnage ships with special devices for manoeuvring and berthing. These devices are only complementary to the berthing tugs.

This Indian Standard is one in the series of standards being developed for harbour tugs. The other standards are:

IS 7363 : 1974 'Inland vessels — Methods of test for harbour tugs — Acceptance criteria (*under revision*)'

IS 8950 : 1993 'Inland vessels — General requirements for harbour tugs (*first revision*)'

IS 12267 (Part 1) : 1987 'Guidelines for stability for inland and harbour decked vessels'.

Wherever the following abbreviations are used in the text, they are to be interpreted as indicated below:

s.s.......Single Screw
t.s.......Twin Screw
LBP.....Length Between Perpendiculars
GM.....Metacentric Height
GZ......Righting Lever

Indian Standard

INLAND VESSELS — HARBOUR TUGS — GUIDE FOR SELECTION

(First Revision)

1 SCOPE

1.1 This standard provides guidance on the various salient features which have to be considered in the selection of harbour tugs to meet the varying needs of the ships.

2 GENERAL

2.1 Local Conditions

It is necessary to note the following environmental conditions in which the tug is meant to operate:

a) Tide direction and maximum height variation;

b) Current;

c) Prevailing wind speed and direction;

d) Fresh or salt water;

e) Open exposed docking;

f) Worst weather conditions under which docking has to be carried out, especially, wind speed, direction and tide condition;

g) Clearance for manoeuvre; and

h) Depth of water.

2.2 Ship Dimensions

Since these tugs have to be normally used for berthing, the following main dimensions of the maximum size of ships, which are likely to be handled in that particular port have also a bearing:

a) Length overall;

b) Length between perpendiculars;

c) Moulded beam;

d) Moulded depth;

e) Loaded draught;

f) Ballast draught;

g) Loaded displacement;

h) Ballast displacement;

j) Loaded trim; and

k) Ballast trim.

2.2.1 *Total Bollard Pull*

The total bollard pull required for handling vessels may be computed from the following equation:

$$P_B = \frac{273 \cdot 157\ AV^2 \ Sin\ \alpha}{(1 \cdot 273 + Sin\ \alpha)} + (A_H + A_S)\ P_W\ Sin\ \theta$$

where

P_B = total static pull required in Newtons (N),

A = lateral under water area in m^2,

V = approach velocity in knots,

α = angle of ship's motion relative to ship's centre line in degrees,

A_H = lateral area of hull above water in m^2,

A_S = face area of superstructure in m^2,

P_W = pressure caused by wind speed in N/m^2, and

θ = angle of wind relative to ship's centre line in degrees.

On the basis of above expression, the bollard pull required for handling large vessels may be computed.

NOTE — Two or more tugs may be used according to availability of tugs in various ports.

3 DESIGN REQUIREMENTS

3.1 To assess the tug's ability to transmit impulses for ship handling work, the following aspects have to be examined:

a) Performance:

   1) Static bollard pull, both ahead and astern pulls

   2) Free running speed

   3) Specific pull

   4) Propeller diameter

b) Manoeuvrability:

c) Thrust control

d) Sea behaviour:

   1) Displacement

   2) Stability

   3) Two rope heeling

e) Construction:
   1) Bulwarks and deckhouses
   2) Bow
f) Towing gear
g) Outfitting and equipment inclusive of fire fighting equipment

3.2 Performance

3.2.1 *Static Bollard Pull*

In fact, the bollard pull depends on the installed horsepower, the propulsion efficiency, the loading of the propeller swept area and the hull efficiency. To an owner, the criteria of bollard pull only conveys a related engine of a certain horsepower in a commercial sense only. The bollard pull astern is equally important as the ahead bollard pull, since the braking power has practically the same significance as accelerating ability of the tug especially while handling large ships. For push-pull ship handling work, the tow rope pull shall be of the same magnitude in both directions. Any assessment of the overall ship handling efficiency of a tug shall be related to both ahead and astern bollard pull. However, the relationship between bollard pull and horsepower can be established approximately with the following formula:

For open screw $P = 0{\cdot}014\ (\text{BHP} \times D)^{2/3}$

For Kort nozzle $P = 0{\cdot}02\ (\text{BHP} \times D)^{2/3}$

where

P = bollard pull in tonnes; and

D = propeller diameter in metres.

3.2.2 *Free Running Speed*

The tug propellers are not normally designed for this condition. However, the free running speed is maintained by engine over speeds, controllable pitch propellers or some similar artifice. Further, a higher pitch ratio screw is less sceptible to face cavitation in the free running condition. But still it is the responsibility of the owner to draw the attention of the builder to the dangers of excessive cavitation occurring and damaging the Kort nozzle or open propeller.

3.2.3 *Specific Pull*

A simple relationship between specific pull and and power loading enables to set a standard against which the quality of performance may be judged in any particular case. The specific pull on the bollard is related to the power loading on the propeller by the following formula:

$$T_S = (C\,P/D^2)^{-\frac{1}{3}}$$

where

T_S = specific pull in kN/100 kW,

C = constant,

P = delivered power in kW, and

D = propeller diameter in m.

From trial analysis of a considerable number of single screw (s.s.) tugs fitted with open propellers or Kort rudders and a limited number of twin screw (t.s.) tugs and water tractors, values for C have been derived as shown below:

Type	*C*
s.s. tug with Kort rudder	116
s.s. tug with open propeller	85
t.s. tug with open propeller	80
Water tractor with single propeller	59

3.2.3.1 A non-dimensional coefficient known as 'figure of merit' as given below, which is generally used in aircraft field, may also be used for relative assessment of the performance of tug:

$$K = \frac{T^{3/2}}{P\,D\sqrt{\rho}}$$

where

K = figure of merit,

T = thrust in kN,

P = delivered power in kW,

D = propeller diameter in m, and

ρ = density of water in kg/m^3.

The typical values of K are given below:

Type	*K*
s.s. tug with Kort rudder	0·13
s.s. tug with open propeller	0·085
t.s. Voith Schneider propeller	0·08

3.2.4 *Propeller Diameter*

The propeller diameter is designed to develop the maximum bollard pull in relation to the available power. The selection of propeller diameter is restricted by the after-draught of the vessel. Further, the power to give the required bollard pull could be obtained by adopting twin screw propellers, single screw with Kort rudder or Voith Schneider propeller. Generally, it can be shown that for high bollard pull from a single screw, coupled with a restriction of operating-draught, can only be met efficiently by the use of Kort rudder or Voith Schneider propeller.

3.3 Manoeuvrability

Ship handling tugs shall have the ability to manoeuvre rapidly within confined space. This

quality is judged approximately by the following tests carried out as a part of the trials routine:

a) The time to complete a circle of 360° at maximum rudder angle, once the ship has settled into turn. To a certain extent, this time is dependent on the ship's speed as well as the type of rudder and rudder area. The rudder area in terms of lateral place area is generally of the order of 6 to 6·5 percent.

b) The diameter of the turning circle. An approximate assessment is made in terms of length of ship.

c) The time taken for the tug to reach dead stop when running ahead at maximum speed and full astern is applied. This again is an approximate measurement. For the purpose of guidance the manoeuvring characteristics of four typical tugs are given below:

Type	*Time on Circle in Seconds*	*Dia of Circle in Terms of Length (L)*	*Full Astern to Stop in Seconds*	*Remarks*
s.s. tug with Kort	58	2·5 L	33	—
s.s. tug with open propeller	61	2 to 2·5 L	31	—
t.s. tug with:				
Open propellers, and	47	2 to 2·5 L	22	At maximum rpm using helm alone
Twin rudders	80	0·5 to 1·0 L	—	At reduced rpm using engines and helm
Water tractor with single propeller	46	—	8	—

It is observed from the above that the water tractor is superior to all the other types in manoeuvrability. The Kort rudder tug has the unique ability to steer astern. In case of reverse or reduction gear box, engine has to be stopped before reversing. The time taken to stop is a reflection of the speed at which the shaft rotation may be reversed and the ability of the propeller to pick up astern power.

3.3.1 Ship handling tugs are put in a perilous position when taking a tow rope or when trying to stop the tow. The former case is a source of danger particularly for a tug with poor manoeuvrability or poor astern performance. This danger is accentuated especially with fast moving on-coming tow of a large tanker. A false move on the tugs' part in such a case may pose a serious hazard. To obviate this danger the tug has to be provided with a satisfactory degree of positive manoeuvrability both ahead and astern, together with sufficient rate of acceleration. This will enable the tug to steer itself clear of danger and that too quickly. Thus, while deciding the power of the tug for a required bollard pull, the question of providing adequate acceleration is also to be considered. An acceleration factor defined as follows may be used as a guide:

$$\text{Acceleration factor} = \frac{\text{Bollard pull} \times 100}{\text{Displacement}}$$

This factor has to be considered in relation to displacement since a high value of this factor may be obtained by reducing the displacement which will in turn effect the handiness of the tug.

During trial tests, measurement of tactical diameters may be taken. Further, Diuedonne Spirals or Kempf manoeuvres may also be carried out. Full scale measured tactical diameter trials could be carried out in enclosed docks with means for measuring the completion of the circle. Based on reliable trial results, coefficients have been suggested to enable the designer to compare computed tactical diameters at the design stage.

3.4 Thrust Control

The larger the force which a tug is required to transmit to the assisted ship, the more precise shall be the control in order to avoid damage to tow rope and towing gear. Therefore, in assessing a tug's efficiency consideration shall also be given to its ability to deliver a stepless adjustable thrust and particularly a small thrust with exactitude.

The changeover from ahead to astern running and vice-versa, that is, manoeuvres which are frequent when coming alongside or getting away, raise problems for engine, coupling, gear, thrust bearing and propulsion units as well as for tow ropes and towing gears. A tug, which can pull equally in one direction and push in the opposite direction during ship handling, does not have to waste time in changing its own position.

3.5 Emergency Steering Position

An emergency mechanical steering position is to be provided in the steering gear compartment.

3.6 Displacement

A tug with comparatively low displacement, when undergoing full power trials on the bollard,

sheers from one side of the dock to the other and full control can only be regained when the power is reduced considerably. This illustrates the fundamental importance of providing adequate displacement in relation to maximum bollard pull. From the available data it may be assumed that a value of 0·6 to 0·7 kN per tonne displacement may be used and such vessels are not likely to have any control problems. The principal hull dimensions link the displacement with the bollard pull. To accommodate the propeller or Kort rudder of adequate diameter, the after-draught has to be adequate. For conventional ship handling tugs the following dimensional relation represents good practice:

a) The ratio of length between perpendiculars (LBP) to breadth moulded shall be of the order of 3·25 to 3·50.

b) The ratio of breadth moulded to depth moulded shall be of the order of 2.

c) The after-draught moulded shall be approximately equal to the depth moulded.

d) The rake of keel shall be about 1 in 20.

e) The freeboard shall be sufficient to provide an angle of deck edge immersion of not less than 10 degrees.

f) The block coefficient shall be in the range of 0·48 to 0·52.

NOTES

1 Sufficient data are not available to enable the characteristics of water tractors to be rationalised in a similar way but the displacement on a given L.B.P. is generally of the same order as for the conventional hull, whilst the lower specific pull of the Voith propeller normally ensures that the relationship between pull and displacement is well below the limiting value indicated.

2 The importance of displacement for tugs is felt in practice but there does not seem to be any rational explanation for it. Probably, the vertical and longitudinal distribution of this displacement plays an important part. It may be possible to explain this by considering the impulse equation:

$$I = \Sigma\, Z \,.\, dt = m \,.\, dV$$

where

I = impulse,

Z = tractive effort,

dt = change in time,

m = mass, and

dV = change of velocity.

This integral can be calculated for each individual ship handling operation, but this does not determine the performance of ship handling tug in advance.

3.7 Stability

The stability standards for any particular vessel are only judged by comparison with other vessels of the same type. However, the position could be viewed from two points of view, namely:

a) the characteristics of the stability curve; and

b) the characteristics of the system of forces acting on the vessel.

With a tug we may assume that the heeling moment due to external forces is simply related to the development of the maximum bollard pull in an athwartships direction and the stability standards adopted by some of the countries are based on this approach. The stability standard for a normal load condition is indicated as follows:

a) The metacentric height (GM) when corrected for free surface shall not be less than 60 cm for an LBP of 15 m nor less than 90 cm for an LBP of 30 m with linear interpolation in between.

b) The maximum value of righting lever (GZ) shall not be less than 20 cm for an LBP of 15 m, nor less than 36 cm for an LBP of 30 m with linear interpolation in between.

c) The maximum value of GZ shall occur at about 30 degrees.

d) The angle of vanishing stability related to the hull alone shall be about 60 degrees.

e) The deck edge immersion shall be not less than 10 degrees. This is generally assured by providing a minimum freeboard of 46 cm for an LBP of 15 m and 76 cm for an LBP of 30 m with linear interpolation in between.

Although the development of the assumed heeling moment is even less likely in the case of the water tractor, it is generally found that the suggested performance level may be met without difficulty.

Considering a tug being towed sidewise at a steady speed of V_t, in modern practice the GM could be approximated to be equal to $V^2_t/20$. It is obvious, the value of V_t will vary from tug to tug. But this relationship breaks down at very low speeds. Together with the GM a reasonable range of positive righting arms and a minimum value of GZ are also required. A minimum value for GZ may be regarded as GM/3. The latter value shall be achieved at the angle of deck immersion. While turning at speed, large angles of heel can be developed. Reduction of this angle can be achieved by a low centre of gravity. By computing the tactical diameter and hence the centrifugal force acting, the angle of heel may be assessed at design stage and this angle shall not exceed three quarters of the angle of deck immersion.

3.8 Tow Rope Heeling

A system in which the tow rope is attached to the tug at a position aft of the point of application of thrust, is intrinsically safe since the tendency shall always be for the force and aft axis of the tug to be pulled into line with the tow rope. This characteristic will be obvious when a tug remains stationary in the water without the necessity for helm control while carrying an astern bollard pull test. However, the moment produced by the applied forces shall be such as to bring the vessel into line with the tow. The stability in general, will depend on the position of the towing hook and not whether the propulsion is at the bow or is at the astern of the tug. Tugs shall be fitted with self-righting quick-releasing hooks which are capable of being released under condition of maximum pull.

3.9 Construction

3.9.1 *Bulwarks and Deckhouses*

The bulwarks shall always be sloped inboard to prevent being stove in and permitting the tug to absorb collisions along the strongest line, that is, intersection of the tug side plating and deck. The distance between the bulwark rail and the deckhouse shall be a minimum of 0·76 m on smaller vessels and as large as possible consistent with the width provided.

Overhead windows in the heel-houses are essential when handling very large tankers and bulk carriers. Erections on decks shall be so arranged as to give a clear view aft between them. The windows fitted in wheel-houses shall be at a lower height than in normal to give a good view of the deck without having to move away from the controls.

3.9.2 *Bow*

As the harbour tug will be normally pushing as much as it is pulling, the bow will require to have a more flattened elliptical shape in order to maintain a reasonable area of the bow bumper in contact with the ship. The bow is provided with strengthening pad for fixing the bowfender. Generally, hollow cylinderical rubber sections are fixed vertically, as cushioning pads, the fenders being retained in place by steel bars going through the middle of them. A similar fender is also fixed at the stern of the vessel. This system ensures maximum freedom to distort under load. Rotating pneumatic bow fenders may also be used.

3.9.3 *Engine Casing*

An engine casing is to be provided above the engine to facilitate repair and removal of engine and other machinery from the engine room.

3.10 Towing Gear

Towing gear forms an essential fitting of the harbour tug. Generally 6 × 24 steel wire rope with fibre core is used. The diameters depend on the bollard pull for steel wire ropes and for a load of 3 to 3·5 times bollard pull of the tug. The rope gear is designed for a load of 2·5 times bollard pull for synthetic ropes. Shackles and fittings are usually selected to give a breaking load equivalent to that of the synthetic rope. Thus the breaking load of these equipment becomes more than six times their safe working load.

Apart from the attachment function of the tow rope, it has also to act as shock absorber. The extensions of the rope whether steel or synthetic for a specified bollard pull may be used as guide to assess their ability to absorb shock. Generally it is found that the extension calculated for composite ropes are satisfactory for confined operation of tugs.

To minimize the danger of the tug capsizing with a sudden snapping of the tow rope, the design of tow hook plays an important part. A simple form is to use a pivoted radial arm without any track support, thus transferring the line of towing pull, when on the beam, nearer to the metacentre and thereby reduce the angle of heel. At the end of this arm, the hook can be mounted in such a way so that this could be tripped by compressed air from a distance and when tripped the hook springs to rest without imparting any shock loading to the mechanism.

Rope guiding gear such as swivel fair lead, towing rails to support the junk, etc, are also necessary fittings.

3.10.1 For pulling duties, centre line towing post in the forward end of the tug shall be designed and fitted to withstand the maximum astern pull of the tug.

3.11 Outfitting and Equipment Inclusive of Fire Fighting Equipment

The dimensions of superstructures on ship-handling tugs have to be adjusted to cater for carrying the fire fighting equipment to deal with large tankers and bulk carriers in their light load conditions. Majority of large ship handling tugs now carry fire fighting equipment, mounted high enough to enable water and foam jets to be directed on to the deck of these large vessels in their light condition. In some cases the monitor platform fitted on top of the wheel-house at a height of 9·2 m above water line and

in other cases on top of a mast at a height of about 20 m. The effect of vibration on the superstructure at this height has also to be taken care of when manoeuvring. The reaction of the monitors when in full operation shall be taken into account while assessing the stability of the vessel.

3.12 Cathodic Protection

Sacrificial anode or impressed current cathodic protection shall be provided as desired by the owner. The positioning, numbers and sizes of sacrificial anodes are to be decided in consultation with specialists in this field.

Standard Mark

The use of the Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act, 1986* and the Rules and Regulations made thereunder. The Standard Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well defined system of inspection, testing and quality control which is devised and supervised by BIS and operated by the producer. Standard marked products are also continuously checked by BIS for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

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Amendments are issued to standards as the need arises on the basis of comments. Standrds are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Handbook' and 'Standards Monthly Additions'. Comments on this Indian Standard may be sent to BIS giving the following reference:

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BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
Telephones : 331 01 31, 331 13 75

Telegrams : Manaksanstha
(Common to all offices)

Regional Offices :	Telephone
Central : Manak Bhavan, 9 Bahadur Shah Zafar Marg NEW DELHI 110002	331 01 31 331 13 75
Eastern : 1/14 C. I. T. Scheme VII M, V. I. P. Road, Maniktola CALCUTTA 700054	37 84 99, 37 85 61 37 86 26, 37 86 62
Northern : SCO 445-446, Sector 35-C CHANDIGARH 160036	53 38 43, 53 16 40 53 23 84
Southern : C. I. T. Campus, IV Cross Road, MADRAS 600113	235 02 16, 235 04 42 235 15 19, 235 23 15
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